Marwari college Darbhanga

Subject---physics (Hons)

Class--- B.Sc. part 2

Paper—04 ; group----B

Topic—Boolean laws and Theorem (Basic Electronics)

Lecture series—10

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Boolean laws and Theorem

Boolean Algebra is a form of mathematical algebra that is used in digital logic in digital electronics. Algebra consists of symbolic representation of a statement (generally mathematical statements). Similarly, there are expressions, equations and functions in Boolean algebra as well.

simplify the Boolean equations and expression, there are some laws and theorems proposed. Using these laws and theorems, it becomes very easy to simplify or reduce the logical complexities of any Boolean expression or function.

The Cumulative Law

The below two equations are based on the fact that the output of an OR or AND gate remains unaffected while the inputs are exchanged themselves. The equation of the cumulative law is given below.

A + B = B + A. ---------------(a)

AB = BA -----------------(b)

The Associative Law

The equation is given as

A + (B + C) = (A + B) + C -----------(c)

A (BC) = (AB) ---------------(d)

These laws illustrate that the order of combining input variables has no effect on the final answer.

The Distributive Law

The equation is given below.

A + (B + C) = AB + AC. ------------(e)

The distributive law can be understood by the corresponding logic equivalence shown in the below.

The four basic identities of OR operations is given below.

$$A + 0 = A$$

$$A + 1 = 1$$

$$A + \overline{A} = 1$$

$$A + A = A$$

The authentication of the above all equations can be checked by substituting the value of A = 0 or A = 1.

The three basic identities of AND operations is given below.

$$A . 1 = A$$

$$A . A = A$$

$$A . 0 = 0$$

One can check the validity of the above identities by substituting the value of A= 0 or A = 1

Double Inversion Law

The double inversion rule is shown by the equation below.

$$\overline{\overline{A}} = A$$

The law states that the double complement (complement of the complement) of a variable equals the variable itself.

DeMorgan’s Theorems

The DeMorgan’s theorem defines the uniformity between the gate with same inverted input and output. It is used for implementing the basic gate operation likes NAND gate and NOR gate. The DeMorgan’s theorem mostly used in digital programming and for making digital circuit diagrams. There are two DeMorgan’s Theorems.

DeMorgan’s First Theorem

According to DeMorgan’s first theorem, a NOR gate is equivalent to a bubbled AND gate. The Boolean expressions for the bubbled AND gate can be expressed by the equation shown below. For NOR gate, the equation is

$$Z = \overline{A + B}$$

For the bubbled AND gate the equation is

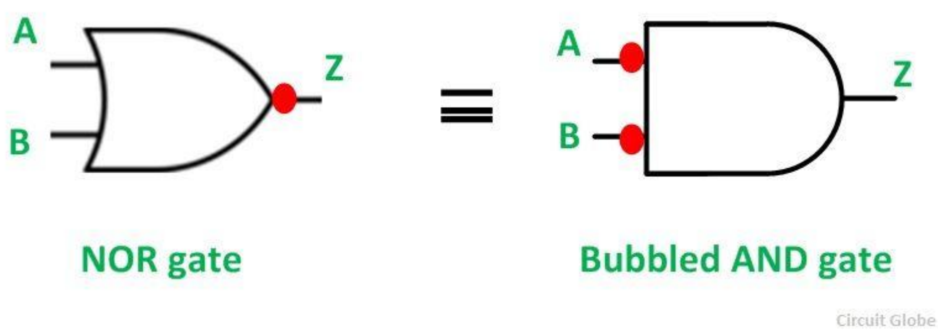
$$Z = \overline{A}.\overline{B}$$

As the NOR and bubbled gates are interchangeable, i.e., both gates have exactly identical outputs for the same set of inputs.

Therefore, the equation can be written as shown below.

$$\overline{A + B} = \overline{A} \,.\, \overline{B} \text{ ....(1)}$$

This equation (1) or identity shown above is known as DeMorgan’s Theorem. The symbolic representation of the theorem is shown in the figure below.



DeMorgan’s Second Theorem

DeMorgan’s Second Theorem states that the NAND gate is equivalent to a bubbled OR gate

The Boolean expression for the NAND gate is given by the equation shown below.

$$Z = \overline{A \,.\, B}$$

The Boolean expression for the bubbled OR gate is given by the equation shown below.

$$Z = \overline{A} + \overline{B}$$

Since NAND and bubbled OR gates are interchangeable, i.e., both gates have identical outputs for the same set of inputs. Therefore, the equations become as given below.

$$\overline{A\,.\,B} = \overline{A} + \overline{B} \quad \dots\dots\dots(2)$$

This identity or equation (2) shown above is known as DeMorgan’s Second Theorem.

The symbolic representation of the theorem is shown in the figure below.